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MINUTES,

MADE AT THE

MEETINGS,

of the

PRINCIPAL

Iron Masters,

IN THE

Counties of YORK and DERBY;

At Sheffield, August 11th, 1799,

AND

At Barnsley, March 6th, 1800.

Part I



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1800.

MINUTES

OF THE

MEETINGS

PRINCIPAL



DEBATE

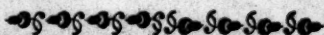
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Sheffield, Aug. 11th, 1789.

THE Chairman, Mr. DAWSON, of the *Low-Moor Iron-Works*, observed, that he was requested to propose to the meeting, that, in order to make their Friendly Associations more interesting, Dissertations on the several processes, machinery, and practices made use of, in making and manufacturing iron, should be delivered at each meeting, by the several members of it, in rotation; and that, to defray the expence attending such a literary connection, each member should subscribe one or more guineas, when the Association should be formed, and that Medals in gold or silver, with appropriate devices, should be struck at the expence of the society, and given to any member, who, at any of their meetings, through the whole of every year, should deliver the best Dissertation on any Subject relating to iron.

Resolved, That this appears an eligible and a desirable plan.

Resolved, That Mr. DAWSON, the Chairman, be requested to give an introductory Dissertation, on the various subjects that may come before the meeting, and lay down a plan for putting the intentions of the meeting in execution.



March 6th, 1800.

The GENTLEMEN of the Association, having met pursuant to Adjournment, and Mr. DAWSON being appointed to the Chair, delivered the following introductory Dissertation.



GENTLEMEN,

YOU will remember, that the last time we met, in order to make our Friendly Association a little more interesting, it was proposed, to form ourselves into a Literary Society, in which we should take into consideration, the several subjects of that Branch of Business, in which we are particularly engaged. For this purpose, I was requested to open the meeting, and to give a sketch of such particulars as might engage our attention, and to point out the mode in which this exercise should be conducted.

The business in which we are employed, is, the making and manufacturing of Iron. In doing this, we make use of a variety of processes, and each process depends upon certain principles. To explain these processes, and the principles upon which they depend, comprehends the great objects which we have before us.

When the Ore or Mine lies in the bowels of the earth, it discovers no metallic affection. It is not at all affected by the magnet, nor has it any other property, which

metals in general, or iron in particular, usually exhibit. It seems, therefore, in a perfectly neutral state. The metallic particles seem perfectly saturated with some substance that prevents the action of it's metallic affinities.

Here there is a fine field for analysis. What are the component parts of each particular sort of stone?—Do they all partake of the same nature?—Are they formed of the same component parts, differing only as more and less; or, are they essentially different?—May it from hence be discovered, why some iron stones make strong, others tender pigs?—Why some produce heavy running metal, others fluid?—Is it from this source, that when rendered malleable, some iron is red short, others cold short, and some always strong and tough, others weak and brittle? These and a variety of other matters, may exercise our ingenuity, and form matter for our future enquiry; an enquiry that will be no less beneficial to the manufacturer, than honourable to the philosopher.

When the iron stone is taken out of the bowels of the earth, it is generally exposed a considerable time in thin beds, to the influence of the air, sun and moisture. This is thought to have a very beneficial influence upon it. The shale with which it is commonly enveloped, crumbles into small pieces, and separates from it, and the stone itself frequently breaks into pieces, and sometimes crumbles into very small parts. It seems also to be altered in it's nature, as part of it will sometimes be found to have a slight affection for the magnet. It will therefore be proper to enquire in this stage of the business, what produces these effects?—Have the pyrites with which it is generally impregnated, undergone a spontaneous combustion?—Or has it given out part of it's oxygen?—Or what other alteration has taken place?—It is believed, by

most iron masters, that it is of great consequence, thus to expose the iron stone for a considerable time, before it is used. Thousands of pounds are sometimes laid dead in this way, under an idea that the money thus unemployed, pays a more beneficial interest, than by being made use of in any more active operation. It will surely then be proper to ascertain the fact, and to endeavour to point out the cause ; not only to justify the practice, but to discover a more beneficial method of obtaining the advantages resulting from it.

When the iron stone has been exposed in the manner above mentioned, for a considerable time, it is torrefied. In the torrefaction, when it has been exposed to a certain degree of heat, for a certain time, it's colour is changed, it has lost from one fourth to one third of it's weight, and it has gained a strong attraction for the magnet. Let us then enquire what has produced these alterations ?—Knowing its component parts before torrefaction, would it not be advantageous to examine what remains ? Has it lost any, and what part of it's sulphur, it's arsenic, it's phosphorus, it's oxygen, or any other principle, to cause such a diminution of weight ?—What has produced the alteration in the colour, from grey or black, to a deep brown ; and all shades to nearly a vermilion ? And what in particular, has given it an attraction for the magnet ?

When the heat in torrefaction has been carried beyond a certain degree, or continued too long, the iron stone changes its colour again, and sometimes acquires an additional weight, but at other times becomes much lighter. In the first case, it is generally of a blue colour, and very compact, in the other, it becomes brown, ap-

proaching to a black, and is very porous. What then has been the cause of these different appearances and effects?—When it is made more heavy, has it attracted more oxygen?—And when more light, has the oxygen burnt the iron?—Have both gone off in vapour, or been absorbed by the fuel?

Iron stone is torrefied two different ways. One upon the ground, in the open air. The other in conical kilns, with open tops, and a fire place at the bottom. In this stage of the business, the judicious iron master, will enquire which mode is preferable, to produce such a torrefaction of the iron stone, as will be most friendly to the smelting of the iron, and which will be attended with the least expence in labour, and the smallest consumption of fuel?—If he find kilns preferable, their construction will not be a matter of indifference.

The next article used in the smelting of iron, to which our attention should be directed, is fuel. This is charcoal, made either from wood or pit coal. The former is very little used in this country, on account of it's scarcity, and therefore will not claim much of our time. The latter, is in universal use, and forms a matter of serious enquiry.

The coal which this country furnishes, differs not less in it's external appearance, than in it's use. In point of hardness it exhibits every degree, from the crumbling of earth, to the solidity of a stone; and in point of purity, it is found abounding with a variety of admixtures, from what is called a stinking coal, to cannel. It's effects are equally various. Some coal burns so pure, as to emit nothing offensive to the nostrils, nor leave any

residuum but a few light ashes ; while others send forth a suffocating stench, and leave behind a coke of closer cohesion than the coals from which they came. This opens a wide field for the philosopher, and not a little demands the attention of the iron master.

The two great requisites in coals, for the purpose of iron, are, that they be sweet, and furnish a strong cinder or coke. Upon what then do these two properties depend ?—What is it that causes coal in burning, to send forth a suffocating smell, and which is so unfriendly to iron ?—Is it pyrites, consisting of sulphur and iron ? Or, to produce this effect, is arsenic or phosphorus necessary ?—Or does it depend upon some other cause ? And which is the best method of purifying coals from these disagreeable ingredients ?

But tho' it be of the first importance, to have a sweet coal, with which to smelt iron, it is no less necessary to have a coal that will make a strong coke. What then are the component parts of that coal, that is sweet, will cinder hard, and make a firm coke ?

Nor is it less necessary, that the coke should abound with carbon. This, I apprehend, is a distinct principle. A coal may be sweet, make a strong coke, and yet not furnish sufficient carbon, of which to make plenty of grey metal.

These are important considerations, and to be able to judge of coal, in a strict relation to each, are matters of the first moment ; for want of this, much money has been laid out to little purpose ; and even in works, at which the materials furnish every requisite, for want of

a proper knowledge of the subject, many advantages are lost, that might otherwise be secured.

When the coal is dug from the mine, it is necessary to burn it into cinders or coke. This is done different ways. Coal is commonly coked in open fires upon the ground. But this operation is sometimes performed in kilns, either open or in a great measure closed. The open fires are generally preferred, tho' there are advocates for the kilns. Certain it is, that the kilns will make the strongest coke ; but then it is said, not to be so friendly to iron, as when made in open fires. It will neither carry so great a burthen, nor make iron of equal quality. Should we not then enquire whether this be fact, and if so, what is the cause of the difference ?—Is it that in the open air, any offensive matter can more easily escape ?—Or, is it that the cokes, made in the open air, being excluded by degrees, from the contact of the air, as the coals burn by being covered with ashes, are prevented from taking oxygen out of it as they cool ?—Or to what other cause ought we to apply the effect ?—If the fact be certain, the cause may be discovered, and, when known, may be productive of the happiest effects.

But let the the coal be coked in whatever way you please, there is a certain degree of heat, to which the fire should be raised, and a certain time to continue in that heat, to make coke of a proper quality. If the coals are not sufficiently coked, they cannot be proper, for the very same reason, that it is necessary, to coke them at all. And if they be coked too hard, as the workmen call it, they are not found to be so beneficial. Here is a nice distinction, to which we ought to attend, and in order to make it beneficial, to the degree to which it is capable, it will be necessary to enquire into the reason, upon

which the observation is founded, and not only to ascertain the fact, but to discover the cause, and make a proper application of it.

In all the iron works in which pit coal is used, a flux is necessary. The nature of this flux will depend upon the constituent parts of the iron stone and cokes. In iron stones there are known to be three distinct kinds, according as they have argillaceous, sileceous, or calcareous earth for their basis, and it will be advantageous to enquire, what is the proper flux in each?—Or whether, as different lime stones contain besides calcareous earth, a variety of admixtures, one may not be found, that will be well adapted for each particular species, and at the same time, on account of it's calcareous quality, be a valuable ingredient for other admixtures, that are contained in the coal and stone?

These observations, shew in the strongest manner, the necessity of being acquainted with the materials upon which we operate, and clearly point out the great advantages that will result, from the judicious application of the principles, when once fully investigated.

But besides these particulars, to which we have drawn your attention, and which are generally supposed to contain, the whole that is necessary, in the making of iron, I would submit it to your consideration, as a subject for future discussion; whether there may not be other important circumstances that claim your notice? In all metals, iron excepted, when they are pure, they are, I believe, pretty nearly of the very same quality. Gold when pure, has the same properties; whether it comes from the mines of Peru, the lead hills in Scotland,

or Wicklow in Ireland. Such is the case also of silver, and I believe of every other metal. But iron differs very much in its quality, both in the raw pig, and purified bar, according to the work at which it is made. Besides the variety to which every work is liable,—some works generally furnish a pig remarkably fluid, but as remarkably weak. While the metal from other works, runs sluggishly, but is proportionably strong, and between the two extremes, there is every shade of difference. Does this arise from an essential difference in the iron?—Or is it owing to different impurities, intimately mixed with the iron, and which no art with which we are yet acquainted, has enabled us to separate?

If you consider that pig iron at every work, differs almost as much from itself at different times, and under different circumstances, in point of fluidity and strength, as one work differs from another; you may, perhaps, be led to suspect that the appearance arises from admixture. Is not every blast furnace a great chemical laboratory, in which different substances, in a dry way operate upon one another, according to their different affinities, and the degree of temperature, to which they are exposed?—And if so, will there not arise different compounds, according to the different substances contained in the furnace, and the different degrees of heat to which they are exposed?—If this be true, is it not above all things necessary, to make ourselves intimately acquainted with the component parts of all the materials which we use? When these are once discovered, perhaps, more additions than one will be found necessary; and we may, perhaps, find that we have yet to learn the best method of managing a blast furnace.

The materials being well examined, and properly prepared, are in the next place, submitted to be smelted in the blast furnace. In this, it may deserve our attention, to enquire, what is the best form and dimensions of the furnace, in which the materials are to be smelted, what is the quantity of air to be introduced, and what is the best mode of application.

As to the furnace, the form and dimensions are very various. Furnaces have been made of all heights, from eighteen to seventy feet, and of all widths from seven to fifteen feet. They have in general been conical, but the top has been much wider, and the boshings much steeper in some than in others. The height and size of the hearth and tuyere, have also been different, so that tho' the general form has been preserved, the dimensions of every particular part has been very much varied. It will therefore be both curious and useful to enquire, what has been the cause of this variety, and what has been the effect of each alteration? Does the difference in materials make these differences necessary? Or, under the same materials, what have been the effects of the alterations? A candid account of every one's experience and observations in these particulars, may furnish useful hints for improvement, be productive of the best mode of operation, and perhaps lead to great and unexpected usefulness.

But important as may be our enquiries respecting the form and dimensions of a furnace, I apprehend it will be of much greater consequence, to investigate the nature of the air, and the proper application of it, in blowing that furnace.

Heat is produced in the furnace, by the combustion of the fuel or cokes. It is, I believe, pretty generally received, that this combustion is carried on, by the cokes absorbing the oxygen part of the atmospheric air; and this air, by being thus fixed in the cokes, and from an elastic fluid becoming a solid concrete, throws out a large quantity of heat, which it held before in a latent state, and which was necessary to give it it's aerial form. If this be the case, the heat of the furnace will depend upon the quantity and quality of the air thrown into it, and the disposition of the cokes to receive the oxygen part of it. Should we not then enquire, at what temperature of the furnace you can make the largest quantity of the best metal?—To assist our enquiries, give me leave to ask, whether, when the metal comes out of the furnace, what the workmen call a blood red, is it not generally short lived, of a dull colour, comparatively brittle, and less in quantity from the furnace running slow, and the yield poor?—Whether when it comes out of a yellow red, the circumstances are not directly reversed?—And whether, when it comes out of a colour approaching to white, the metal is not in the same state as in the first case, with this difference, that the furnace runs quick, and the quantity of metal is more abundant?—If these queries, correspond with fact, will they not help us to account for a variety of appearances, which will tend to direct our enquiries, and improve our practice?

When the coals are properly coked, if upon application of air, they become hot, and do not soon waste, it is plain their attraction for oxygen is great and lasting, and therefore very proper for the blast furnace. If they should soon become hot, and soon dissolve, or if notwithstanding their duration, they should not be capa-

ble of being readily and intensely heated, do they not appear to be proportionably improper?—Should we not, therefore, enquire upon what principles these properties depend?—Would not such enquiry, either enable us to correct the deficiency, or to lay the coals aside as useless?

Will not such enquires, also, enable us to discover upon what principle, coke burned too hard, is injurious to a furnace?—Is not such coke heavier than those properly burnt?—Does not this addition of weight, arise from an absorption of oxygen?—And when put into the furnace, being partly saturated with oxygen before it is put in, will it not have less attraction for that principle, take it up in less quantity from the air, and consequently produce less heat than is requisite for the production of good metal?

Will not the same principle account for the bad effects of putting raw stone into the furnace?—In this state it has neither parted with it's necessary quantity of oxygen, nor with the sulphurous, arsenical, or phosphoric particles with which it might be combined, and therefore, when properly ignited, must give them out to the materials in the furnace. This additional quantity of oxygen, when seized by the cokes, raises the temperature of the furnace too high, and the impurities attach themselves to the metal. The consequence is, that the metal comes out very hot, is what the workmen call frangy, and is seldom much better in quality, than very indifferent forge pig.

On the same principles cannot we account for the appearance the furnaces assume, under the different states of

the weather?—In the winter when the weather is frosty, the air is full of oxygen, the furnaces work well, and make plenty of good metal. In these circumstances, when too much air is thrown into the furnaces, their temperature is raised too high, and the metal comes out as above specified, hard and frangy.

In moist weather, we frequently experience the contrary to all this. The furnaces run dull and heavy, the metal comes out of a low temperature, and seems nothing but a very imperfect regulus.

Is it not fact then, that when evaporation, as it is called, goes on very quickly, which it always does in frosty weather, that the air by some operation of nature, not yet discovered, becomes strongly charged with oxygen?—The good effects of this, are at once apparent in the furnace. But that when the air deposits its moisture, and this moisture entangled in the air, goes into the furnace, as soon as it comes to the red hot cokes, it is decomposed; and in this decomposition, takes up a very considerable quantity of heat in a latent state, and so cools the furnace at the very place where the metal should receive it's fluidity, that it comes out thick and heavy, is what the workmen call short lived, and strongly oxygenated. In a fine spring, when every plant throws out it's oxygen air, the furnaces work well, and make plenty of good metal. But in a dry summer, when the air is loaded with noxious particles, when vegetation ceases, when not a leaf is scarce ever seen to move, a deficiency of oxygen is manifest, and the furnaces move exceedingly slow indeed. Metal is made in very small quantity, and it's quality is exceedingly bad. Now could we by any operation, find a method of producing oxy-

gen air, in sufficient quantity, and at a cheap rate, and throw it into the furnaces as circumstances required; should we not be able to correct this deficiency, which natural operations occasion?—This will deserve our most serious attention.

But we ought not only to attend to the state of the air, but it is said, much will depend upon the manner in which this air is thrown into the furnace. Some do this by means of small air receivers working alternately into an air chest, others by means of a dry regulator, others by an air vault, and some by a water receiver. The first two methods, and perhaps the third, may all be considered as one, as the air is sent into the furnace, without being in contact with water. In the third, it presses upon the surface of the water, and in consequence of that, by its density, will dissolve some part of it, and go into the furnace with it, in solution. This always appeared to me, a very great advantage, but the propriety of the sentiment has lately been called in question, and I only mention it here to draw your attention to it, that future observations may be brought either to confirm or confute the sentiment.

Give me leave just to hint, that this subject appears to me, hitherto, to have been very imperfectly understood. When the matter is examined, I apprehend the determination of the question, will depend on the following circumstance: What is it that nature effects, when air is said to take water up in solution? Is water in it's compound state taken up by the air, so as to form a compound body of air and water?—Or, does the air in the act of solution decompose the water, and only take one of it's constituent parts, and at the same time change it into it's aerial form?—The first sentiment is generally

the received opinion. But perhaps the latter may be found true, and if so, it will throw great light on many operations in chemistry, and may be made very beneficial to the iron master. But I only give you this hint, to draw your attention to the subject. I mean, at a future meeting to treat it more at large.

At any rate, when water is dissolved in air, so as that the air is perfectly transparent, it is always friendly to blast furnaces. It is only when the water is entangled in the air like mist, and goes into the furnace along with the air in pure water, that it is injurious. Now whenever the air is compressed in a water receiver, whatever water it takes up, in consequence of its density, it will dissolve, and therefore, will go into the furnace dry air, which I always thought would be beneficial. But this we shall leave for future observation.

I will only just add, that it has been thought a matter of great importance, whether the air be thrown into the furnace with great or little velocity. To effect the former, you lessen the diameter of your tuyere pipe, and enlarging of it will produce the latter. There are advocates for both sentiments, and perhaps, in different circumstances they may both be right, and I hope our future observations will point out the circumstances that are favourable to each.

These are the principal thoughts that have occurred to me, respecting the smelting of iron. I might in the next place proceed to the foundry, and after that to the forge and steel furnace. Every one of these operations, would furnish many observations deserving of attention. But I fear, I shall have exhausted your patience.

The hints which have here been suggested, have been laid down in the form of queries, without deciding upon any one particular point. This was principally intended to excite your attention, and to leave the business open for future investigation. No doubt we have formed to ourselves certain sentiments, respecting every one of the particulars that have been mentioned, and which is remarkable, perhaps, every individual may differ. This is the origin of so many different modes of proceeding, and may be the cause of different degrees of success, arising from viewing the subject in different lights, without any communication. The intention of our present meeting, is to assist one another in future, by a free and friendly communication of different opinions, in order to excite industry, and produce an examination that may be mutually beneficial.

Individuals have done much in the making and manufacturing of iron, in the last sixty years, and yet the subject is very far from being exhausted. Perhaps, it may be said with truth, that we have no compleat knowledge of any one operation ; and consequently, in the whole we may be said, in some measure, to grope in the dark. Should not this excite our attention ?—Should it not lead us to make experiments?—Dispose us to communicate what we know, and receive with attention, the communications of others?—By thus uniting our efforts, the chance of success is great, and surely, I am speaking to gentlemen, who will be happy to adopt the sentiment, and support it with every effort in their power.

Before I dismiss the subject, permit me to observe, that tho' a chemical mode of treating the several subjects that come under our consideration, be undoubtedly the most proper, and perhaps, the only way by which nature can

be traced thro' all her windings, yet I should be extremely sorry, if it was concluded from hence, that none but persons acquainted with chemistry, could form proper members of this Association. All chemical reasoning is founded upon facts. Facts therefore, well and attentively collected, form the great basis of all our chemical superstructure. But facts are open to the mechanic as well as the philosopher; to the workman, as well as his master. It requires only, an attentive mind, a sound judgment, good common sense, and faithful representation to collect them; and when collected, they form the basis of all science. Upon these, the philosopher reasons; to reconcile them to one another, he makes experiments; and when a variety of discordant appearances, widely scattered, and uncouthly related, can be all connected by one general principle, the labourer, the mechanic, and the philosopher unite in promoting the cause of truth; and every art, to which science is applicable, receives improvement, every artist is benefited; and human nature at the same time, that it acquires dignity, feels it's condition ameliorated, and every individual rendered more happy. Let us then unite our efforts, each in his proper sphere. Let us pay attention to our respective works, according to our situation. Let us mark the facts, and, as far as we are able, reason upon them. But particularly, let us be diligent in collecting, and faithful in relating. By thus exerting all our powers, each in his own sphere separately, a joint communication may be highly pleasing, and mutually beneficial.





After the PRESIDENT had finished the INTRODUCTORY DISCOURSE, the following RULES were proposed, and adopted, by which the SOCIETY are to be governed,

I.

THAT a President shall be chosen annually.

II. Also a secretary, whose office shall be perpetual, or during the good liking of all parties.

III. That there be four meetings every year, in March, June, September, and December; at each of which, the members shall dine with one another, and in order that the president may know what number of dinners to order, every person who subscribes his name to the Conditions of this Association, whether he attend or not, shall pay two shillings and six-pence for his dinner.

IV. Every member, shall pay upon his entrance, one guinea, to defray any expence belonging to the society, and one guinea annually, every March meeting after; which money shall be given to the treasurer, at this time to be appointed.

V. That every member in rotation, shall deliver an essay on some subject relating to iron, at every meeting, and the subject of the essay, shall be mentioned by the person that delivers it, at the meeting before it be delivered.

VI. That every member shall be permitted to deliver his sentiments on the essay with freedom, and the person delivering it, shall have liberty to reply.

VII. That every member in rotation, shall propose a question relating to iron, for the discussion of the members present, and it shall be expected, that he shall give his own thoughts on the subject, before any other member speaks, but after this, the conversation shall be open.

VIII. That every member shall be expected to be present at ten o'clock in the morning, business shall begin at eleven, and dinner shall not be on the table before three.

IX. After it shall be determined, who shall deliver the first essay, and the first question, every member, in the order, in which his name stands among the subscribers, shall deliver the next essay in course. But the member who delivers the first essay, shall deliver the second question, and so on at every succeeding meeting.

X. The secretary shall provide a book, at the expence of the society, in which he shall record any Resolution that shall be made, the subject of every essay and question, the name of the members that are to deliver them, and any other thing that shall be thought proper to be recorded.

XI. That medals of gold, with proper devices shall be struck, at the expence of the society, to be presented to any member, who, through the whole of the year, shall have delivered, either an essay or question, that shall be esteemed of the greatest importance, to be determined by a majority of the members present, at every June meeting, and any other essay or question of inferior importance, shall be rewarded by a medal of inferior value.

XII. That the place of meeting in March, shall be at Barnsley; in June, at Bradford; in September, at Sheffield;

and in December, at Rotherham. And that each of these meetings, shall be on the first Wednesday, prior to every full moon, in each month.

XIII. That any member, who has hit upon any thought, that he thinks of importance, and of which, he wishes to take the opinion of the company, after the essay and question shall be ended, shall be at liberty to submit it to the consideration of the meeting.

After these Particulars were read and agreed to, the following Resolutions were made.

I.

THAT Mr. Dawson, of the Low-Moor Iron-works, be President for the following Year.

II. That Mr. Littlewood, of the Sheffield-Park Iron-works, be Secretary.

III. That Mr. Chambers, of Thorncliff Iron-works, be Treasurer.

IV. That Mr. Dawson, the President, be requested to deliver the first Essay, at the next Bradford Meeting, which he accepted, and proposed for his Subject: The Effects of Air and Moisture, on Blast Furnaces.

V. That Mr. Emmett of Birkenshaw Iron-Works, be requested to propose the first Question, at the next Bradford Meeting, which he accepted, and pro-

posed for the subject of his Question : Whether it was better, to use one or two Tuyere Pipes, by which, to throw Air into Blast Furnaces?

VI. That Mr. Dawson, be requested to print the Introductory Essay, he has at this Time delivered to the Meeting, and get one hundred Copies taken off, at the Expence of the Society, and for their Use.



R. SEDGWICK, Printer, Market-Place, BRADFORD.

9/8/73